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Association between physical fitness and lifestyles with academic achievement in chilean high school students

Asociación entre la condición física y los estilos de vida con el rendimiento académico en estudiantes de enseñanza media chilena

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Abstract
Academic achievement plays a key role in access to higher education, influenced by psychological, biological, and social factors. Physical fitness and healthy lifestyles are positively associated with cognitive functions, potentially improving academic achievement. This study is descriptive-correlational and has an observational cross-sectional design. The sample consisted of 145 students (46 women and 99 men). Data collection included anthropometric measurements, physical fitness tests, and lifestyle assessments. Academic achievement was measured using participants' final averages in some matters. The multiple linear regression analysis revealed key factors influencing academic achievement across matters. For language ($R^2 = 0.216$), higher achievement was associated with female students ($\beta = -0.246$; $p = 0.033$), lower BMI ($\beta = -0.047$; $p = 0.016$), better flexibility (Scratch Test: $\beta = 0.024$; $p = 0.024$), and lower physical activity levels ($\beta = -0.263$; $p = 0.001$). In mathematics ($R^2 = 0.101$), better achievement was related to lower physical activity levels ($\beta = -0.403$; $p = 0.003$) and superior performance in the jump with feet together ($\beta = 0.008$; $p = 0.047$). For English ($R^2 = 0.146$), higher achievement correlated with lower physical activity levels ($\beta = -0.369$; $p = 0.002$), lower BMI ($\beta = -0.058$; $p = 0.081$), and better sleep quality ($\beta = 0.058$; $p = 0.020$). Academic achievement is influenced by factors such as a lower BMI, better flexibility, superior performance in horizontal jump, sleep quality, and reduced physical activity levels. These findings emphasize the multifactorial nature of academic success, highlighting the importance of physical fitness, mental health, and lifestyle factors.
Keywords: adolescents; physical fitness; academic achievement; lifestyles.

Resumen
El rendimiento académico desempeña un papel clave en el acceso a la educación superior y está influenciado por factores psicológicos, biológicos y sociales. La condición física y los estilos de vida saludables se asocian positivamente con las funciones cognitivas, lo que podría mejorar el rendimiento académico. Este estudio es de tipo descriptivo-correlacional y tiene un diseño observacional transversal. La muestra estuvo compuesta por 145 estudiantes (46 mujeres y 99 hombres). La recolección de datos incluyó mediciones antropométricas, pruebas de condición física y evaluación de estilos de vida. El rendimiento académico se midió utilizando los promedios finales de los participantes en algunas asignaturas. El análisis de regresión lineal múltiple reveló factores clave que influyen en el rendimiento académico según la asignatura. Para lenguaje ($R^2 = 0.216$), un mayor rendimiento se asoció con ser mujer ($\beta = -0.246$; $p = 0.033$), menor IMC ($\beta = -0.047$; $p = 0.016$), mejor flexibilidad (Test de Alcance: $\beta = 0.024$; $p = 0.024$) y menores niveles de actividad física ($\beta = -0.263$; $p = 0.001$). En matemáticas ($R^2 = 0.101$), un mejor rendimiento se relacionó con menores niveles de actividad física ($\beta = -0.403$; $p = 0.003$) y mejor desempeño en el salto con pies juntos ($\beta = 0.008$; $p = 0.047$). Para inglés ($R^2 = 0.146$), un mayor rendimiento se asoció con menores niveles de actividad física ($\beta = -0.369$; $p = 0.002$), menor IMC ($\beta = -0.058$; $p = 0.081$) y mejor calidad del sueño ($\beta = 0.058$; $p = 0.020$). El rendimiento académico está influido por factores como un menor IMC, mejor flexibilidad, mayor rendimiento en el salto horizontal y calidad del sueño, así como por niveles reducidos de actividad física. Estos hallazgos enfatizan la naturaleza

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multifactorial del éxito académico, destacando la importancia de la condición física, la salud mental y los estilos de vida.

Palabras clave: adolescentes; condición física; rendimiento académico; estilos de vida.

Introduction

Academic achievement results from several components that interact with each other: psychological, biological, economic, and sociological, which influence the teaching/learning process (Estrada, 2018). It is considered an indicator of the learning acquired by the student, which is why it is used as a reference for the quality of education (Colonio, 2017). Moreover, in today's society, there has been a growing concern about the role of academic achievement in access to higher education. Academic achievement is influenced by various factors, including personal motivation, study habits, substance use such as alcohol, tobacco, and drugs, socioeconomic status, parental education level, the type of educational institution, and residential location (Caso-Niebla & Hernández-Guzmán, 2007; Cigarroa et al., 2022). These factors can significantly impact students' ability to perform academically. For example, low socioeconomic status and limited parental education are often associated with reduced access to academic resources and support. Similarly, substance use has been linked to diminished cognitive performance (Caso-Niebla & Hernández-Guzmán, 2007; Cigarroa et al., 2022). Physical activity (PA) has recently gained relevance due to its multiple physical, psychological, and social benefits (Malm et al., 2019; Concha-Cisternas et al., 2020; Hernandez et al., 2024).

There is ample evidence of the multiple benefits of PA. Studies indicate that high levels of PA are associated with a lower risk of metabolic diseases and better overall health status (Poitras et al., 2016; Concha-Cisternas et al., 2024). Benefits have even been reported at the cognitive level (Mandolesi et al., 2018) and in academic achievement (Barbosa et al., 2020). More specifically, it has been observed that sufficient frequency and intensity of PA can significantly contribute to better academic achievement (Zurc & Planinšec, 2022). Despite these results, the particularities of educational policies in each country could influence PA practice, as it has been reported that, in many cases, students tend to prioritize their academic activities over PA (Concha-Cisternas et al., 2018). This is particularly relevant in the Chilean context, where the educational system, with a strong

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orientation towards academic achievement and preparation for standardized tests, could limit opportunities for integrating healthy habits into the school routine.

Similarly, healthy lifestyles and habits have been reported to be relevant to the cognitive performance of schoolchildren (Lima et al., 2022). For example, better sleep quality, duration, and consistency are strongly associated with better academic achievement in students (Okano et al., 2019). Also, poor sleep quality and reduced sleep can generate cognitive impairment and poor cognitive functioning (Li et al., 2022). On the other hand, periods with high levels of stress are associated with poor academic achievement of students (Crego et al., 2016). Depression and anxiety have even been shown to be significantly associated with lower academic achievement (Khesht-Masjedi et al., 2019).

On the other hand, physical fitness is the capacity of the body to make its different systems work efficiently and effectively, generating a state of health, which allows performing daily activities with ease (Corbin & Le Masurier, 2014). Physical fitness is composed of different capacities, including musculoskeletal strength, flexibility, cardiorespiratory fitness, balance, and speed (Le-Cerf et al., 2022). Like PA, physical fitness is considered an important marker of health (Ortega et al., 2008), and an association between physical fitness and cognitive functioning has already been observed (González-Fernández et al., 2023). For example, there is a positive association between cognitive function and cardiorespiratory fitness in adults (Stern et al., 2019) and with maximal isometric handgrip strength (MISH) in older people (Lee et al., 2022).

Although there is evidence of an association between physical fitness and academic achievement in university students (Redondo-Flórez et al., 2022; Zhai et al., 2022) and schoolchildren (Van Dusen et al., 2011), certain limitations persist. Among them, the lack of consideration of key variables such as age ranges, PA levels, hours of sleep, and mental health of the participants stands out. Furthermore, the aforementioned studies were conducted in Spain, China, and the United States of America, countries with different academic and cultural contexts. The educational context in Chile, marked by a strong emphasis on academic achievement and preparation for standardized tests, may make it difficult to integrate these habits into students' daily lives. This approach may cause students to prioritize study and academic achievement over healthy lifestyles,

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which could generate different results from those already reported in other educational realities and contexts. Therefore, this study aimed to analyze the relationship between physical fitness and lifestyles with academic achievement in Chilean high school students.

Material and methods

Study design

This is a quantitative, descriptive-correlational study with a cross-sectional observational design. The research was approved by the ethics committee of the Universidad Santo Tomás (No. 23-27). In addition, the guidelines described by the Helsinki Declaration were followed for the conduct of this study (Shrestha & Dunn, 2020).

Participants

The type of sampling was non-probabilistic by convenience, where 145 students from a private subsidized educational establishment of the commune of La Florida, Santiago, Chile, were evaluated. The inclusion criteria were: (a) students of both sexes between 13 and 17 years of age who were in high school (upper secondary education), (b) who agreed to participate voluntarily in the study, and (c) authorized by their legal guardians. Exclusion criteria were: (a) if the participant had pain or any acute pathology at the time of the physical assessments, (b) if the participant had any musculoskeletal injury during the last 3 months, and (c) medical contraindication to perform the physical fitness tests to be evaluated.

Data collection

Assessments were classified into four categories: basic assessments, physical fitness, lifestyle, and academic achievement. The physical fitness tests were conducted on non-consecutive days to ensure adequate rest, avoid fatigue, and prevent injury.

On the first day, the flexibility tests: sit-and-reach, and back scratch tests were performed. After 48 hours, the Cooper test was performed to cardiorespiratory fitness.

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Again, 48 hours later, the jumping test with feet together, the 20-meter sprint test, and the MIHS were applied.

All physical fitness tests were performed in the gymnasium of the educational establishment, two days after the explanation and familiarization session with the different tests. The questionnaires were completed in the classroom, using the participant's cell phone through the platform "Google Forms."

Baseline assessments (bipedal height, body weight, body mass index (BMI), age, and grade) were performed on the same day as the familiarization and explanation of the tests. Bipedal height was measured using a stadiometer (Seca, Hamburg, Germany; accuracy of 0.1 cm) and body weight with a digital scale (Seca, Hamburg, Germany; accuracy of 0.1 kg). Both measurements were used to calculate BMI, which is obtained by dividing body weight (kg) by bipedal height squared (m2).

Physical fitness

Prior to the evaluation, the participants performed a general warm-up, which included joint mobility and a light jog for 5 minutes. For cardiorespiratory fitness, the Cooper test (Cooper, 1968) was used, the test consists of running the greatest possible number of meters for 12 minutes; it was performed on the school athletic track (400 meters), and the distance covered was measured by laps around the track, in case of not finishing the lap, the point reached was measured by cones placed on the track at a distance of 100 m from each other.

For speed, the 20-meter sprint test (Altmann et al., 2019) was used, which consists of running from point A to point B, this distance corresponds to 20 meters. The test starts with the participant located behind the line marked at point A, upon hearing the sound stimulus (whistle) must leave at maximum speed to point B, when crossing the line at point B the time is stopped and recorded (seconds).

For flexibility, two tests were used, for the hamstring-lumbar spine sit-and-reach (Baltaci et al., 2003) and to evaluate shoulder flexibility back scratch test (Lavín-Pérez et al., 2023) was used, in the first one, the participant must sit down and with the knees extended must try to touch the tip of the feet or go over them, where, in a numbered box, the centimeters that he/she advances or lacks towards the feet are marked. Once in

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position, the best distance (cm) was recorded. In the second, to evaluate shoulder flexibility, the standing participant should bring his preferred or dominant hand over the same shoulder, palm down and fingers extended. From this position he/she will bring the hand towards the middle of the back as far as possible, keeping the elbow up, the other arm will be placed on the back surrounding the waist with the palm upwards and bringing it as far as possible, trying to bring the middle fingers of both hands touching. If the fingers do not touch, the value of the missing centimeters is recorded. Once in position, the best mark (cm) is recorded.

To evaluate the lower limb muscle strength, the feet together horizontal jump test (Santos et al., 2022) was used, where the participant from point A, marked on the floor, must jump as far as possible with feet together to point B, from the heel the distance between point A and B (cm) is taken and recorded, there are 3 attempts, where the best one is recorded. For the upper limb, a MIHS through hand dynamometer was used (Gąsior et al., 2020), where the participant with the elbow flexed close to the body must squeeze with the greatest force, he/she can for 3 seconds, there are three attempts, where the highest value obtained (kg) was recorded in the dominant hand.

Lifestyles

For lifestyles, different questionnaires were used. The Dass-21 test (Román et al., 2018) was applied to evaluate the emotional symptoms of stress, anxiety, and depression in the participants. The test consists of 21 questions, where the answer ranges from 0 to 3 points, each of the emotions has 7 questions, where the average is considered as the final result, likewise, the higher the score, the greater the symptomatology. The depression item is evaluated through the lack of pleasant and/or positive feelings for life and the lack of interest in the activities in which the respondent performs. Anxiety is assessed by situations of tension and physiological agitation and/or momentary or situational anxiety. Stress is measured through reactivity, difficulty relaxing, and irritability.

The PAQ-A questionnaire assesses PA performed by the participant in the last 7 days. The overall result of the test is a scale of 1 to 5 points which allows a final score to

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be established for the level of PA (Martínez-Gómez et al., 2009). The higher the score, the greater the amount of PA performed in the 7 days.

The Pittsburg questionnaire (Buysse et al., 1989) allows to standardize and check the quality and latency of sleep, classifying them into good or bad sleepers. The questionnaire has 19 items, divided into 10 questions, which are scored from 0 to 3, with 0 being no problem and 3 being severe difficulty. The overall score ranges from 0 to 21 points, 0 indicating ease of sleep and 21 severe difficulties in all areas.

Academic achievement

For academic achievement, the final averages of the participants' common plan matters, i.e., language and literature, mathematics, and English, were considered. In addition, another item was considered with the final general average of course promotion.

The scale used in Chile is from 1.0 to 7.0, with being 1.0 the minimum grade, 4.0 being the passing grade, and 7.0 being the maximum grade.

Statistical analysis

The data were analyzed with SPSS 25.0 statistical software (SPSS 25.0 for Windows, SPSS Inc., IL, USA). The mean and standard deviation were calculated to describe the characteristics of the sample, and the results of the assessments performed. The Kolmogorov-Smirnov test was performed to assess normality (95% confidence interval). Pearson's test (95% confidence interval) was applied for the association between physical fitness and lifestyle variables explaining academic achievement. A multiple linear regression model (95% confidence interval) was applied to determine the physical fitness and lifestyle variables that explain school academic achievement. The models were adjusted for age, sex, and BMI. For each of the variables present in the regression models obtained, a collinearity diagnosis was performed, where variables with values below 0.10 tolerance and values above 10.0 variance inflation factor (VIF) were eliminated. The level of significance for all statistical tests was <0.05.

Results

Descriptive results

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Of the 145 students evaluated (46 female and 99 male), the mean age was 16.02 years, with an average body weight of 62.84 kilos and an average bipedal height of 167.19 centimeters. The mean BMI was 22.48 kg/m². Table 1 presents the detailed anthropometric characteristics of the participating students, expressed as mean and standard deviation. Table 2 presents data on students' academic achievement, physical fitness, and lifestyles.

Table 1. Anthropometric measurements of the participating students

	Mean	Standard deviation
Age (years)	16.02	1.09
Body weight (kg)	62.84	9.02
Bipedal height (cm)	167. 19	8.42
BMI (kg/m^2)	22.48	2.86

BMI: body mass index.

Table 2. Academic achievement of students.

	Mean	Deviation standard
Academic achievement		
Language	5.39	0.69
Mathematics	5.23	1.02
English	5.29	0.99
General average	5.62	0.55
Physical Fitness		
20-m sprint test (s)	4.19	0.46
Cooper test (laps)	19.62	5.55
Sit-and-reach test (cm)	5.43	9.63
Back scratch test (cm)	5.49	5.19
Horizontal jump test (cm)	182.00	30.56
MIHS (kg)	32.87	7.91
Lifestyles		
Stress	9.64	4.2
Anxiety	7.35	4.73
Depression	7.83	4.98
PA level	2.59	0.75
Sleep quality	6.8	3.77

MIHS: maximal isometric handgrip strength; PA: Physical activity.

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Correlation between physical fitness and academic achievement

Table 3 presents the correlations between academic achievement and physical fitness tests of students. There is a negative correlation between speed and grades in language ($p < 0.0001$; $r = -0.343$), mathematics ($p = 0.030$; $r = -0.176$), English ($p = 0.005$; $r = -0.239$) and general average ($p = 0.003$; $r = -0.251$). A positive correlation is observed between aerobic capacity and grades in language ($p = 0.005$; $r = 0.236$), English ($p = 0.029$; $r = 0.178$), and general average ($p = 0.028$; $r = 0.180$). No significant correlations were found between grades and flexibility of the lower or upper limbs, or with strength of the lower or upper limbs.

Table 3. Correlation between physical fitness and academic achievement.

	Language		Mathematics		English		General average	
	p	r	p	r	p	r	p	r
20-m sprint test (s)	<0.001***	-0.343	0.030*	-0.176	0.005**	-0.239	0.003**	-0.251
Cooper test (laps)	0.005**	0.236	0.056	0.150	0.029*	0.178	0.028*	0.180
Sit-and-reach test (cm)	0.358	-0.034	0.389	-0.026	0.388	0.026	0.388	0.026
Back scratch test (cm)	0.084	0.130	0.232	0.069	0.071	0.138	0.099	0.121
SPJ test (cm)	0.111	-0.115	0.365	-0.032	0.322	-0.043	0.359	-0.034
MIHS (kg)	0.058	-0.148	0.279	-0.055	0.122	-0.110	0.139	-0.102

*SPJ: jump with feet together. *: less than 0.05; **: less than 0.01; ***: less than 0.001*

Correlation between lifestyles and academic achievement

Table 4 shows the correlations between academic achievement and students' lifestyles. There is a positive correlation between stress and language grades ($p = 0.045$; $r = 0.159$). A positive correlation is also observed between depression and language performance ($p = 0.032$; $r = 0.174$). In contrast, a negative correlation is found between PA level and grades in language ($p < 0.0001$; $r = -0.357$), mathematics ($p = 0.001$; $r = -0.270$), English ($p = 0.0009$; $r = -0.291$) and GPA ($p < 0.0001$; $r = -0.348$). In addition, there is a positive correlation between sleep quality and academic achievement in English ($p = 0.022$; $r = 0.189$).

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Table 4. Correlation between lifestyles and academic achievement.

	Language		Mathematics		English		General average	
	p	r	p	r	p	r	p	r
Stress	0.045*	0.159	0.336	0.040	0.199	0.080	0.390	0.026
Anxiety	0.205	0.077	0.410	0.021	0.194	0.081	0.477	-0.005
Depression	0.032*	0.174	0.387	0.027	0.132	0.105	0.305	0.048
PA level	<0.001***	-0.357	0.001**	-0.270	<0.001***	-0.291	<0.001***	-0.348
Sleep quality	0.072	0.138	0.246	0.065	0.022 *	0.189	0.064	0.143

: less than 0.05; **: less than 0.01; *: less than 0.001*

Multiple linear regression analysis

Table 5 shows the results of the multiple linear regression analysis for grades obtained in language, mathematics, English, and the general average. The variables that were significant in the models are presented in Table 7. For language performance, the model ($R^2 = 0.216$) indicates that female students ($\beta = -0.246$; $p = 0.033$), with a lower BMI ($\beta = -0.047$; $p = 0.016$), better results in the back scratch test ($\beta = 0.024$; $p = 0.024$), and those who reported a lower level of PA ($\beta = -0.263$; $p = 0.001$) presented a higher academic achievement. In mathematics, the model ($R^2 = 0.101$) indicates that students with a lower level of PA ($\beta = -0.403$; $p = 0.003$) and those with a better performance in the jump with feet together ($\beta = 0.008$; $p = 0.047$) obtained higher grades.

For English, the model ($R^2 = 0.146$) suggests that a lower level of PA ($\beta = -0.369$; $p = 0.002$), a lower BMI ($\beta = -0.058$; $p = 0.081$), and a better quality of sleep ($\beta = 0.058$; $p = 0.020$) are associated with a higher academic achievement. Finally, the general average showed a model ($R^2 = 0.207$) in which female sex ($\beta = -0.281$; $p = 0.037$), better performance in the back scratch test ($\beta = 0.005$; $p = 0.010$), lower anxiety ($\beta = -0.016$; $p = 0.154$), lower level of PA ($\beta = -0.293$; $p < 0.001$), and better sleep quality ($\beta = 0.024$; $p = 0.094$) were determining factors in good general academic achievement.

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Table 5. Multiple level regression for academic achievement.

	R^2	Coefficient B	p	IC 95 %	
Language	0.216		<0.001		
(Constant)		7.191	0.001	6.092	8.291
Gender		-0.246	0.033	-0.505	0.014
BMI		-0.047	0.016	-0.089	-0.005
Scratch test		0.024	0.024	0.001	0.047
PA		-0.263	0.001	-0.42	-0.105
Mathematics	0.101		0.014		
(Constant)		5.05	<0.001	3.814	6.286
SPJ		0.008	0.047	0	0.016
PA		-0.403	0.003	-0.668	-0.139
English	0.146		0.001		
(Constant)		7.187	<0.001	5.581	8.792
BMI		-0.058	0.081	-0.124	-0.007
PA		-0.369	0.002	-0.604	-0.135
Sleep		0.058	0.02	0.009	0.107
General	0.207		0.001		
(Constant)		5.548	<0.001	4.836	6.259
Gender		-0.281	0.037	-0.544	-0.017
SPJ		0.005	0.01	0.001	0.01
Anxiety		-0.016	0.154	-0.039	0.006
PA		-0.293	<0.001	-0.431	-0.154
Sleep		0.024	0.094	0.004	0.052

BMI: body mass index; PA: physical activity; SPJ: jump with feet together.

Discussion

The main aim of this study was to analyze the association between physical fitness, lifestyles, and academic achievement in Chilean high school students. Through a multiple linear regression analysis, factors that influence academic achievement in the matters of language, mathematics, English, and general average were identified. In language, it was observed that, in females, a lower BMI, a better performance on the Scratch Test, and a lower level of PA were associated with better academic achievement. In mathematics, a lower PA level and better performance in the jumping jacks were associated with higher grades. In English, lower PA level, lower BMI, and better sleep quality favored performance. Finally, for the general average, notable factors were female gender, performance on the Scratch Test, a lower level of anxiety, lower PA, and better sleep quality.

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These results reinforce the multifactorial nature of academic achievement, as they reveal that variables such as body composition, flexibility, and sex may each play distinct roles. Consistent with previous studies, our findings support the relevance of BMI, with Anderson and Good (2016) reporting a positive association between healthy weight and academic success, and Hermassi et al. (2021) linking obesity to poorer outcomes. In our data, a lower BMI correlated with better academic achievement, highlighting its potential as a meaningful predictor. Notably, upper limb flexibility, measured by the back scratch test, showed a positive association with academic performance in our sample. This is particularly relevant since flexibility has traditionally been considered less influential due to its weak relationship with health indicators (Stodden et al., 2015). The absence of prior studies directly connecting this test with academic outcomes underscores the novelty of our result and the need for further exploration. Interestingly, this relationship was not observed for lower limb flexibility, in line with findings by Santana et al. (2017), who noted inconsistencies across studies regarding flexibility and academic achievement. Additionally, our analysis revealed a sex-based difference favoring female students. This is partially consistent with findings by Tsaousis & Alghamdi (2022) and Dubuc et al. (2020), who observed higher academic scores among females in subjects such as science and language. However, other studies (Faisal et al., 2017) report no significant sex-based differences, indicating that this variable remains subject to contextual and cultural variation.

In the lifestyle outcomes, sleep quality and academic achievement stand out. This result is interesting, as some studies have indicated that sleep quality is not related to academic achievement, both in students with high and low grades (Alotaibi et al., 2020; Jalali et al., 2020). However, there is research indicating that poor sleep quality can negatively affect academic achievement (Gupta et al., 2023) or that lack of sleep can have a similar impact (Suardiaz-Muro et al., 2020). It is possible that sleep quality, when affected, negatively impacts performance, but that, when adequate, does not generate an additional benefit in this regard.

In relation to anxiety, it was possible to observe the importance it has within the general average, but this result is still debatable, since it has been seen that anxiety does

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not significantly affect academic achievement (Brumariu et al., 2023), but other studies conclude that there is a significant high-level relationship (Vitasari et al., 2010).

An inverse relationship was also observed between PA levels and academic achievement. Although this result aligns with findings from Avila-García et al. (2020) and Esteban-Cornejo et al. (2014), who also reported a negative association between PA and academic indicators, it remains a controversial issue in the literature. Other studies, such as those by Marrero-Rivera et al. (2024) and Barbosa et al. (2020), highlight a positive impact of sustained PA on academic performance. In our study, one possible explanation for this inverse relationship is that higher PA levels may reflect a greater time investment in extracurricular or recreational activities, potentially at the expense of time dedicated to academic tasks. This interpretation is especially relevant in academic contexts where time management and study routines play a critical role in academic success. Furthermore, not all physical activity necessarily contributes to improved cognitive outcomes; some forms of PA may lack the structure or intensity required to yield cognitive benefits. Our findings may be more consistent with the perspective of Daimiel et al. (2020), who suggest that it is not PA per se, but physical fitness, particularly cardiorespiratory and neuromuscular fitness, that has a more direct impact on cognitive function. These authors argue that improvements in brain function are more strongly associated with increased physiological efficiency, neuroplasticity, and cerebral blood flow, which are more directly influenced by structured physical training than by general PA levels. Therefore, we hypothesize that the academic benefits observed in students with better physical performance may stem from a higher level of physical fitness, whether achieved through targeted exercise or influenced by genetic predisposition, rather than from total PA volume alone.

Another hypothesis is that, in this age group, students must choose between dedicating extra hours to study to improve their grades or engaging in extracurricular PA, a tendency that seems to be deeply rooted in Chilean idiosyncrasy and that could explain these results. This could also shed light on the high levels of obesity, sedentary lifestyles, and mental health problems observed in this group. A study in young Chilean university students indicated that those students who dedicate more hours to study are approximately twice as likely to be physically inactive (Concha-Cisternas et al., 2018). This finding

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could explain our results, given that the educational context and ages of the participants are similar to those evaluated in that research.

In Chile, the school curriculum is highly focused on academic achievement in areas such as language, mathematics, and science, especially in preparation for national standardized assessments, such as the Higher Education Access Test (in spanish PAES) (Goizueta et al., 2023). This approach generates considerable pressure on students to prioritize study in these subjects, which frequently implies dedicating less time to extracurricular activities, such as PA. In addition, educational policies tend to value academic achievement over the comprehensive benefits of PA, which is reflected in a low hourly load for this subject compared to other Organization for Economic Co-operation and Development (OECD) countries (Fierro-Saldaña, 2024). Consequently, schoolchildren must prioritize the fulfillment of high academic standards over the development of a physically active lifestyle. This system, where academic achievement is rigorously evaluated, reduces the opportunities for students to incorporate PA on a regular basis, thus contributing to higher academic achievement, but at the cost of lower participation in PA.

The jump with feet together was also a relevant factor in academic achievement, which confirms what was mentioned by Zhai et al. (2022) who reported a significant association between these variables. However, it is curious that the result is only favorable for the lower limb and not for the upper limb, the distinction may be given by the method used to assess the muscle strength of the upper limb, where perhaps it would have been easier to use the push-up test, as it may be much more familiar to students than the use of a hand-held dynamometer, although both instruments are validated, it could justify the results obtained. Chen et al. (2013), who mentions that there is no relationship between muscle strength and academic achievement, this inconsistency of results is discussed by Santana et al. (2017), where it is mentioned, that such an association is uncertain and should be further studied.

In a complementary manner, our study revealed significant relationships between academic achievement and two physical fitness components: cardiorespiratory fitness and speed. Specifically, students with higher performance in the 20-meter shuttle run test and the 4x10 meter agility test also showed higher academic scores. This association suggests

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that better aerobic capacity and motor efficiency may positively influence school performance, potentially through mechanisms related to cognitive control, attention, and information processing speed.

These findings are in line with previous studies. For instance, Redondo-Flórez et al. (2020) reported a positive association between VO2 max and academic achievement, and Santana et al. (2017), in their systematic review, highlighted strong evidence supporting this link. One proposed explanation is the elevation of brain-derived neurotrophic factor (BDNF) through aerobic exercise, which contributes to improved cognitive performance, neuronal growth, and synaptic plasticity (Jeon & Ha, 2017; Brattico et al., 2021). However, beyond the biological mechanisms, our results emphasize that, in this particular student population, physical fitness may reflect broader lifestyle patterns—such as self-discipline, energy regulation, or school engagement—that directly or indirectly impact academic success. Another mechanism of action could be the improvement of the capacity to transport oxygen to the brain, improving its availability and, consequently, cognitive performance (León-Carrion et al., 2008).

Regarding speed, we found a negative correlation with all scores; that is, the shorter the transfer time in the 20-meter test, the higher the academic achievement. This finding is consistent with the results of Zhai et al. (2022), who also identified significant positive associations in the 50-meter speed test. Similarly, Esteban-Cornejo et al. (2017) observed that greater speed and agility are related to greater gray matter volume, which is also associated with better academic achievement.

Finally, correlations were found between academic achievement and mental health factors, such as stress and depression. In particular, a positive correlation was observed between stress and depression with language scores. This finding is complex to interpret, as it suggests that as grades increase, so do levels of stress and depression. This could be explained by the number of daily hours dedicated to study, an aspect that was not addressed in this study. In addition, family, personal, or social pressure to obtain good academic results could be an influential factor that was also not considered. However, this situation contradicts findings indicating that poorer mental health is associated with lower academic achievement (Chu et al., 2023). It is crucial to develop tools that help students manage periods of stress and depression more effectively, especially during final

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exam dates. More in-depth monitoring of students' mental health is required, ideally with the support of professionals.

Among the limitations of the study is the choice of the intervention participants, which was a convenience sampling. It would be ideal in the next instance to look for a method that allows a more random choice and even a larger sample. Also, there is low female participation, so it is difficult to say whether the results are equally conclusive for both males and females.

The use of self-report questionnaires can generate biases since fatigue in reading, attention, concentration or reading comprehension depends entirely on the participants.

On the other hand, the motivational factor of the students when performing the different physical fitness tests, although the tests were voluntary and with consent, there is the possibility that the results are only for fulfilling the test and are far from the maximum values of the students' physical capacities.

Another limitation of the study is that the external physical fatigue caused by the students' weekly activities could not be controlled, although they were informed and asked for a safeguard, there is nothing to corroborate that this was fulfilled.

It is also important to mention that academic achievement does not necessarily reflect the cognitive capacity of the students, since the tests and/or grades depend both on the student and the teacher in charge, and the type of evaluation was not considered either. In addition, the form of evaluation of academic achievement is specific to the country and makes it difficult to compare it with other studies.

Another important point is that the socioeconomic factor of the participants was not considered, where it would have been interesting to explore, where they live or with whom they live. Nor did we consider the hours of study dedicated to school, a variable that could better explain some phenomena of academic achievement.

Conclusion

A lower BMI, better performance in the back scratch test, and better performance in the jump with feet together can benefit academic achievement in Chilean high school students. In addition, speed and aerobic capacity can positively influence academic achievement. In lifestyles, stress and depression increase with good academic

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achievement, good sleep quality and a lower level of anxiety can positively influence academic achievement. Finally, a high level of weekly physical activity decreases academic achievement.

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